Chapter 24

# Global Warming Changes the Forecast for Agriculture

**Reported by Sara E. Wilson**

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*—Cynthia Rosenzweig*

In January 2001, representatives of 99 countries gathered in Shanghai to consider evidence on global warming as part of the United Nations' Intergovernmental Panel on Climate Change (IPCC). Their conclusions, while not new to scientists, set off alarm bells among laypeople and policymakers around the world. The scientific evidence on global warming is now stronger than ever and points to a rise in temperatures of 1.4 to 5.8 degrees Celsius over the next century, higher than earlier predictions. Higher temperatures will be accompanied by rising sea levels and more frequent occurrence of extreme weather events, such as droughts, floods, and violent storms.

The IPCC has studied not only the projected changes in climate, but also how those changes will affect many human activities, including agriculture. "In the most fundamental way, climate change will bring change to agriculture wherever it is practiced around the globe," says Cynthia Rosenzweig, senior research scientist at the National Aeronautics and Space Administration (NASA) and Columbia University.

## Agriculture Will Feel the Heat

Although scientists are uncertain about exactly how the world's climate will change and how that change will bear on agriculture, they are in increasing agreement on some likely effects. On the bright side, global warming could increase water availability in some currently water-scarce areas, increase global timber supply, and raise crop yields in temperate and some subtropical zones, according to a February 2001 report issued by the IPCC.

Higher crop yields and increased timber supplies could result from "the carbon dioxide fertilizer effect." Richard Adams, professor of agricultural and resource economics at Oregon State University, explains, "As the amount of carbon dioxide in the atmosphere increases, some plants will grow faster and produce more yield."

Experiments show the potential benefit of elevated levels of carbon dioxide, but Adams cautions, "The experiments that have studied this effect have controlled for all other conditions. That will not be the case in farmers' fields. Water or nitrogen, for example, may not be sufficient under field conditions to fully utilize the increased carbon dioxide, and therefore the carbon dioxide fertilizer effect may not be as great as it seems in the experiments."

The benefits of the carbon dioxide fertilizer effect may not be on hand for long either, because increased carbon dioxide appears to boost crop yields only if average annual temperatures increase by less than a few degrees. If average temperatures rise beyond that, temperate zones will lose the carbon dioxide fertilizer effect and their crop yields will fall. Other regions do not even have the hope of many potential benefits from climate change. "Very little positive effect is projected in the tropics, even in the short term," says Rosenzweig. The IPCC predicts reduced crop yields in most tropical and subtropical regions, increased risk of flooding, and decreased water supply, especially in the subtropics.

In addition to the direct effects of rising temperatures, changes in levels of precipitation, and more common extreme weather events, agriculture will also suffer from the indirect effects of climate change: pests and pathogens may increase, soil is expected to erode and degrade because of more intense rainfall patterns, and rising levels of ozone may increase air pollution damage to crops. "These indirect effects may potentially be more important than the direct effects that have received most of the attention in existing studies," says Adams.

Crops will not be the only food source affected by climate change. For example, says Meryl Williams, director general of ICLARM—the World Fish Center, "More and more severe climate and weather events will further stress fish production systems, natural and artificial, and increase greatly the challenges for people whose food and livelihoods depend on them." Livestock will also suffer from rising and more extreme temperatures and may also have less forage and feed available to

them. As a result, individual animals may produce less food for human consumption and overall herd numbers may decrease.

Current projections indicate that global food security will not be threatened by the end of the 21st century. However, climate change is expected to be more pronounced in developing nations, which already experience lower agricultural yields and suffer more from extreme weather events. Even if global food security is not imperiled, climate change is likely to cause hunger and displacement in many parts of the developing world.

Climate change will not only affect different geographic regions disproportionately, but will also vary over time. "People don't seem to recognize that climate isn't necessarily going to change in a smooth manner," says Paul Faeth, program director of the Economics and Population Program at the World Resources Institute. Severe weather events, for example, could devastate agriculture in some years and have little impact in other years.

## Agriculture Is a Culprit

Agriculture itself produces about 20 percent of greenhouse gases that are responsible for global warming. Farming activities release substantial amounts of the gases methane and nitrous oxide. Methane is produced by the decomposition of organic matter, particularly in the soil of flooded rice fields and by the digestive process of ruminant livestock like cattle. Converting land to agricultural use emits nitrous oxide, as does the use of nitrogen fertilizer. Agriculture is responsible for about 50 percent of human-related methane emissions and 70 percent of nitrous oxide emissions.

Agriculture plays a relatively small role in by far the biggest contributor to rising concentrations of greenhouse gases: carbon dioxide from the burning of fossil fuels as well as from deforestation and tilling practices. "When you convert from forest or grassland to agricultural usage, you lose a lot of carbon," says Stanley Wood, an IFPRI senior scientist. "After conversion, much less carbon is usually stored in the soil and in crops and pasture, and carbon is released when crops are harvested and processed." Limiting the loss of carbon due to agricultural practices is one way that farmers can begin to help mitigate the problem of climate change.

## Putting the Brakes on Climate Change

"Because agricultural ecosystems are responsible for 18–24 percent of green-house gas emissions, there have to be some significant things agriculture can do to mitigate the problem," says Sara Scherr, adjunct professor in the Agricultural and Resource Economics Department at the University of Maryland and a fellow at

Forest Trends. "Reduction in emissions from the burning of fossil fuels has to be the highest priority, but it would be foolish to overlook what agriculture can contribute."

By cutting overuse of nitrogen fertilizer, for example, farmers can help lower nitrous oxide emissions. They can reduce methane emissions from livestock by using improved feed.

Strategies to store more carbon in soil, trees, and other plants will also help reduce global warming through a process called carbon sequestration, the increased retention of carbon in soils and vegetation. Examples of this strategy include limiting deforestation through better agricultural techniques (higher yields means less land needed for agriculture) and reducing the amount of carbon lost during conventional tilling of agricultural lands.

Carbon sequestration can also occur by intentionally creating carbon "sinks" to increase the amount of carbon stored on the planet. Regrowing forests is the most obvious example of this policy, but another promising solution can be found in agroforestry, the use of trees on agricultural lands. This practice is finding increasing support, according to Pedro Sanchez, director general of the International Centre for Research in Agroforestry, because it not only helps store carbon, but can also improve yields on agricultural lands by enhancing soil fertility, preventing soil erosion, and helping to control weeds. By planting trees on their lands, poor farmers can increase their own food security while also helping to reduce the amount of carbon dioxide in the atmosphere. "What's important in these efforts," says Sanchez, "is to bring together the human element of people who are hungry and poor and, at the same time, get a global environmental benefit for all of us."

Agroforestry is an example of what is often called a "win-win" strategy among climate change experts: it not only slows climate change, but also provides an immediate and direct benefit to farmers. "It's true of all long-term problems: you have to look for immediate rewards to convince people to make changes that will have a longer-term benefit," says Faeth. "There are lots of things that help productivity and also have a climate benefit. The synergies are pretty amazing."

Robin Reid, systems ecologist at the International Livestock Research Institute, agrees that win-win strategies might have an important role to play but offers a caveat. After describing a strategy whereby the use of better feed in livestock improves meat and milk production while also reducing methane emissions, she says, "But you need to be skeptical of win-wins because they don't always spell out the full carbon accounting of the situation. For example, to produce better quality feed for livestock, you might have to use more fertilizer to grow it. Ultimately, the emissions from the increased fertilizer might overcompensate for the reduction in emissions from the livestock."

## Adjusting to a Global Greenhouse

The effects of climate change are already being felt. According to the IPCC, it is likely that the 1990s was the hottest decade in the Northern Hemisphere in the past one thousand years. International efforts to mandate reductions in greenhouse gas emissions have been underway since the 1980s. Even if emissions are drastically cut, however, farmers will have to adapt to the changes in climate that are preordained by the levels of greenhouse gases already in the earth's atmosphere.

"Our current research continues to support the idea that farmer adaptations will be the main mechanisms for keeping world agricultural production from falling very much even if mean global temperature increases by 5 degrees Celsius," says Roy Darwin, an agricultural economist at the Economic Research Service of the United States Department of Agriculture.

Agricultural adaptations include increasing irrigation where water is available, growing different crop varieties, changing planting and harvesting dates, expanding access to markets, and shifting agricultural production from one area to another. Some of these coping efforts can be undertaken by individual farmers, while others will require the joint action of farmers and outside organizations, including development agencies, private industry, and national governments.

"Farmers will adapt. There's no doubt about that," says Rosenzweig. "But it's important to note that we're not even completely adapted to our climate today. Agriculture already has to respond to many dynamic factors, such as changing markets, regulations, and demands. Climate change puts another stress on agricultural systems."

The capacity to adapt to the kinds of changes predicted, the IPCC points out, will require access to information, infrastructure, and technology—resources that poor people in developing countries already lack. Because many of these people live in the tropical and subtropical countries most likely to experience the negative effects of climate change, they are in a position of double jeopardy.

Unfortunately, developing countries are doing little to plan for either mitigation or adaptation. "One reason is the learning curve on the science of climate change. It's just an incredibly complex issue that takes a long time to get a handle on," says Scherr. "Even in developed countries, where a lot of sophisticated research has taken place for many years, policymakers are only beginning to be aware of the urgency of climate change and willing to do something about it."

## The Standoff over Global Climate Change

"The real problem," according to Brian Fisher, executive director of the Australian Bureau of Agricultural and Resource Economics, "is getting people to face up to problems that may not greatly affect us for one hundred years or more. This is espe-

cially true in developed countries in temperate zones, which won't feel much impact even if some of the worst climate projections come true." Efforts led by the United Nations Framework Convention on Climate Change (UNFCC) to complete negotiations on the Kyoto Protocol, a proposed international agreement on restrictions of greenhouse gas emissions, stalled in late 2000 but are scheduled to resume in summer 2001. A major stumbling block is the fundamental disagreement between developed and developing countries about the fairest way to cut greenhouse gas emissions.

Developing countries, which are responsible for a relatively small amount of the greenhouse gases currently in the atmosphere, believe those who caused the problem should carry the lion's share of the burden of solving it. On the other hand developed countries fear that restricting greenhouse gas emissions, particularly those caused by the burning of fossil fuels, will slow their economies, and they want more flexible methods to meet proposed reduction requirements. Whether any agreement at all can be reached under the Kyoto Protocol was recently thrown into doubt by the announcement of the United States that it plans to withdraw from the talks scheduled for this summer.

While efforts to set international emissions restrictions are progressing slowly, some promising initiatives are already underway, especially in the area of carbon trading. Trading carbon allows those who emit greenhouse gases to earn counteracting credits by investing in carbon sinks. Pedro Sanchez of ICRAF gives an example: "A European airline that flies to Nairobi several times a week is exploring ways to compensate farmers in Kenya for the carbon they sequester in agroforestry systems to counterbalance the greenhouse gases the airplanes emit in the stratosphere."

In the end, no one will remain unaffected by climate change. To cut emissions and encourage adaptations in agriculture, many other cooperative efforts will be needed. Governments and development organizations will need to help farmers, especially in resource-poor areas, cope with the temperature increases, reduced water supply, extreme weather events, and reduced soil moisture that are likely to exacerbate food insecurity in those regions of the globe that are already worst-off. Current projections do not extend beyond the 21st century, but if mitigating and adaptive steps are not taken soon, climate change and the agricultural problems associated with it will only increase, putting the food security of future generations further at risk.